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Cast Aluminum Alloys for High Temperature Applications Using Nanoparticles Al_2O_3 and $\text{Al}_3\text{-X}$ Compounds ($\text{X} = \text{Ti}, \text{V}, \text{Zr}$)

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ABSTRACT

In this paper, the effect of nanoparticles Al_2O_3 and $\text{Al}_3\text{-X}$ compounds ($\text{X} = \text{Ti}, \text{V}, \text{Zr}$) on the improvement of mechanical properties of aluminum alloys for elevated temperature applications is presented. These nanoparticles were selected based on their low cost, chemical stability and low diffusion rates in aluminum at high temperatures. The strengthening mechanism at high temperature for aluminum alloy is based on the mechanical blocking of dislocation movements by these nanoparticles. For Al_2O_3 nanoparticles, the test samples were prepared from special Al_2O_3 preforms, which were produced using ceramic injection molding process and then pressure infiltrated by molten aluminum. In another method, Al_2O_3 nanoparticles can also be homogeneously mixed with fine aluminum powder and consolidated into test samples through hot pressing and sintering. With the $\text{Al}_3\text{-X}$ nanoparticles, the test samples are produced as precipitates from in-situ reactions with molten aluminum using conventional permanent mold or die casting techniques. It is found that cast aluminum alloy using nanoparticles $\text{Al}_3\text{-X}$ is the most cost effective method to produce high strength aluminum alloys for high temperature applications in comparison to nanoparticles Al_2O_3 . Furthermore, significant mechanical properties retention in high temperature environment could be achieved with $\text{Al}_3\text{-X}$ nanoparticles, resulting in tensile strength of nearly 3 times higher than most 300-series conventional cast aluminum alloys tested at 600 F.